Chapter 7. Summary

The trends presented in this report show that Japan has caught up with, or surpassed, the United States in some leading indicators of scientific and technological strength, and lags behind in others. Japan leads the United States in the percent of GDP invested in total and non-defense R&D, as well as government investments in civilian R&D as a percent of GDP. Japan is particularly strong in technology and trade indicators, and has a higher proportion of engineers in its labor force than the United States. Japan is still behind the United States, however, in R&D expenditures in higher education, in competitive research funding in universities, and in its share of the world's scientific articles. Japan has far smaller graduate S&E programs than the United States, especially in natural sciences. The research productivity of these departments is influenced by the number of qualified doctoral students, as well as the quality of professors (Ushiogi, 1993). Japan is attempting to address these weaknesses by increasing government science budgets targeted specifically for universities and national laboratories, with expansion of both doctoral programs and the national capacity for basic research.

Implications

Barring a major economic setback or other unforeseen situation, it appears that Japan can double government R&D support by the year 2000, or shortly thereafter. This suggests a stronger human and physical infrastructure for basic science in Japan and continued support by Japan for major international science programs. The overall result could be a continuing increase in the Japanese contribution to advancing science and engineering knowledge.

The current S&T strengths of Japan, coupled with their concerted efforts to advance their capacity for breakthrough research, have implications for their domestic science as well as global S&T. Some of these implications relate to issues in human resources for science and technology, higher education, collaborative research and science funding.

Human Resources

The additional funding is aimed at strengthening Japan's human and physical infrastructure for basic science. Domestically, Japan will continue expansion of doctoral programs and attempt to create centers of excellence in research. Until recently, most doctorates in the natural sciences and engineering in Japan were earned by industrial researchers in Japanese companies. By 1994, more doctoral engineering degrees were earned for research within university laboratories (53 percent) than for those in industrial research laboratories (47 percent). The planned funding of 10,000 fellowships for doctoral students and postdoctorates by the year 2000 would continue this trend.

The main Japanese science funding agencies are increasing the amount of competitive research funding to improve university research environments, and to overcome the deficiencies in present facilities and research personnel. New funding programs will facilitate collaboration of scientists from industry, universities and national laboratories, and provide for employment of research assistants and laboratory technicians on fixed-term projects (3–5 years). About 5–7 strong research institutes will receive large 5-year science funding to become centers of excellence, that is, research centers for world-class research in a particular field.

Higher Education

Japan is expanding funding and programs for U.S. and other international students to study in graduate programs in science and engineering in Japan. However, U.S. students have not taken advantage of ongoing educational exchange programs with Japan. One issue for the United States to address is whether or not interest can be mobilized among graduate and undergraduate S&E students for greater transnational competence.

International Collaborative Research

Japanese science agencies have growing R&D budgets to provide a boost to the funding and realization of world class research facilities, within Japan and abroad. For example, accelerator research will benefit from a new particle accelerator facility being built at the National Laboratory for High Energy Physics in Tsukuba Science City. The facility, called the KEK

B-Project, will explore asymmetrical behavior among particles and antiparticles. In addition, the SPring 8 synchrotron radiation facility under construction in Kobe will be completed in 1998 and open to overseas researchers.

The increase in government sponsored research in Japan, at a time when the United States and Western European governments have constrained science budgets, creates several opportunities for the international research community. Japan is providing additional funds to intensify international research cooperation on global issues, such as food, energy, environment and infectious diseases, and in basic sciences, such as the Human Frontiers and Human Genome Project. Japan is establishing international centers for R&D in Tsukuba Science City, and expanding both postdoctorate fellowships for foreign researchers and accommodations for foreign scientists at national laboratories.

This expanded government R&D funding and increased access to unique facilities suggest that issues concerning research cooperation for enhancing the advancement of basic knowledge and quickening the pace of scientific discovery, as well as ways for improving information about the scientific and technological accomplishments of Japan, could grow in importance in the near future. New issues are likely to arise concerning the best ways to enhance awareness and intensify U.S. involvement and cooperation with scientists and engineers in excellent facilities and research centers in Japan. For example, how might information flows be improved for the U.S. science community to identify promising candidates for further cooperation that would benefit both parties?

Science Funding and Accountability

Japan's decisions to double the government budget for R&D provides the United States and European countries an example of a different strategy in national science policy when facing difficult times. Like the United States and many European countries, Japan has a large national debt, a public eager to balance the national budget, and a private sector interested in keeping the government small. The prolonged economic recession in Japan has resulted in slower growth rates in its economy in the 1990s than in any other industrial nation. Nonetheless, Japan has chosen to protect and increase government funding of science as an investment in the future.

The additional funding, however, is made with high expectations for future benefits to society, and with requirements to evaluate the effectiveness of large public outlays. The rationale for increased funding of strategic basic research is its importance in recovery from recession and for its contribution to long-term sustainable development of Japan. It is expected that large funding of research projects with industry—university collaboration will lead to technological innovations, creation of new industries and a more prosperous society. Thus the Science Council is required to develop guidelines for an evaluation system of outcomes of large funding projects. This raises the issue of how the United States might best track the Japanese experience as an input to the development of government performance and evaluation measures in the areas of science and technology.

Need for Further Research

The Asian region is the fastest growing region of the world, with large potential markets for trade. While there is uneven growth among Asian countries, and uneven growth within large countries such as China, the combined economies of 12 countries in the Asian region were over $10 trillion in constant dollar terms in 1994 (table 16). Several countries within this region

Table 16. GDP of selected Asian countries: 1994

Country	GDP
	[Millions of constant 1987 dollars 1/]
Total	$10,367,511
China	4,353,706
Hong Kong	96,238
India	863,002
Indonesia	532,986
Japan	2,052,499
Malaysia	132,059
Pakistan	53,339
Philippines	1,363,716
Singapore	43,504
South Korea	371,644
Taiwan	194,452
Thailand	310,366

1/ GDP for each country, provided in current national currencies by the International Monetary Fund, was converted to constant 1987 dollars.

SOURCE: International Monetary Fund, *International Financial Statistics Yearbook* (IMF: Washington, D.C., 1996).

have higher GDP growth rates than the United States or European countries (see NSF, 1993 and NSF, 1996c).

Japan is continuing to place its manufacturing industries and assembly offshore, mainly through investment in plants and equipment in developing Asian countries. Japan's direct foreign investment (FDI) in Asian countries reached $10 billion[26] in 1995, up from $5 billion in 1987 (Manifold, 1966). Through technology transfer and the education of significant numbers of foreign students from neighboring countries in engineering, health, and agriculture, Japan will continue to be one of the Asian region's growth engines. (See Chapter 4.) The Japanese Office of Development Assistance (ODA) is continuing its strong outreach program for more integration with China and South Korea, and for technical assistance to developing countries in the Asian region. There is need for research on the effectiveness of this three-pronged approach (direct foreign investment, technical assistance, and science and engineering education) to Japan's competitiveness in the Asian region, and Japan's role in fostering a prosperity sphere in East Asia.

[26] Market exchange rate conversion, not PPPs.